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EFFECTIVE LINING OF TUNNEL KILN CARS MADE OF ALUMINOSILICATE CERAMOCONCRETE

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Aluminosilicate ceramoconcrete lining for cars used in ceramic plant firing kilns was developed and introduced. The first cars with this lining have already operated for more than 50 cycles.

Modernization of existing firing kilns and introduction of new tunnel kilns with a channel width of up to 7 m are important factors in increasing the efficiency of current ceramics plants. The mobile hearth in thermal engineering units is formed of kiln cars whose lining must work in the most severe conditions. The lining is exposed to impact loads in charging the packs of semifinished products and removal of the finished products as a result of mechanical contact of the cars with each other and is also repeatedly subjected to variable thermal loads. For this reason, the refractory lining of the firing cars must have a set of frequently difficultly compatible properties: high mechanical, thermomechanical, and structural strength, thermal stability of linear dimensions and good heat resistance; low thermal conductivity and as low weight as possible to reduce the load on transporting equipment and increase the charge capacity. The technological effectiveness of assembling and repairing the lining and naturally its cost are also important indexes.

World and domestic experience shows that attaining high resistance of tunnel kiln car linings is determined by the success of combining two fundamental approaches: a competent materials technology approach and a successful design concept.

Two priority directions are now being distinguished: use of special firing refractories, primarily of cordierite composition. Burton (Germany) is the acknowledged international manufacturer here. This company's high-quality refractories exhibit good stability, but the relatively high cost has held back their wide introduction in Russian plants in current repairs even in kiln cars in which Burton refractories were initially installed [1].

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The other, more promising direction in our opinion is to use unmolded refractories or articles made of refractory (heat-resistant) concretes in the linings. However, the use of heat-resistant concretes in Portland cement, alumina cement, and liquid glass is not expedient in most cases in the current stage [2, 3].

Good performance results (turnover of 100 – 200 cycles) were obtained for concretes in high-alumina cement and for alkali slag cement in a composition with light heat-insulating materials — claydite and ceramovermiculite [3, 4]. The following finding is nevertheless widely acknowledged: the presence of hydraulically hardening calcium-containing cements in concretes causes decomposition processes in any case in thermal loading to 1000 – 1100°C and results in degradation of the structure of the lining material. For this reason, it is totally logical that the resistance of kiln car linings (up to 400 – 500 cycles) made of heat-resistant concrete will increase significantly with all other optimum conditions being equal (grain and material composition of the material, design solutions) in converting to the new type of concrete with a low cement content (2 – 8%) [5]. Such concretes are a multicomponent composite containing polyfractional refractory filler, ultradisperse synthetic powders, and dispersing and plasticizing additives. However, although low-cement concretes are used in the thermal units in ferrous and nonferrous metallurgy is economically justified, the expediency of using such expensive materials in the ceramics industry is very debatable.

Moreover, alternative cementless concretes — ceramoconcrete, based on primarily new manufacturing principles which have no analogs abroad, have been developed and have already demonstrated high efficacy in practice [6]. Although the rheological and binding properties in foreign

TABLE 1

Index	Ceramoconcrete composite	
	ShKBI-5	ShML-40
Mass fraction in fired substance, %:		
Al_2O_3, min	35.0	38.0
SiO_2, max	52.0	50.0
Fe_2O_3, max	2.0	2.0
Apparent density, g/cm^3	1.60 – 1.70	1.90 – 2.05
Compressive strength, MPa, min, after heat treatment:		
110°C	20.0	30.0
1000°C	25.0	40.0
Open porosity, %	≥ 24	≤ 22
Initial softening point under load, °C, min	1370	1450
Thermal stability, 1000°C – air cycles	> 100	> 100
Additional linear shrinkage (growth) at 1150°C, %	Absent	

Fig. 1. Appearance of car before (*a*) and after (*b*) reconstruction.

low-cement concretes or their Russian analogs are usually determined by special ultradisperse synthetic components, highly concentrated ceramic suspension binders (HCSB) made from available and relatively inexpensive raw materials fulfill the function of binder in ceramoconcretes.

As many years of experience in service in the thermal units at different ceramics plants, aluminosilicate ceramoconcretes in chamotte – quartz HCSB were best [7, 8].

In consideration of the positive scientific and practical experience and the results of industrial testing of chamotte – quartz ceramoconcrete compositions, a shop for production of refractory pastes and molded articles with different applications made of aluminosilicate ceramoconcrete with a capacity of up to 3000 tons of product a year was organized by Teplokhimmontazh Co. at its production base.

In 2002, OSMiBT Ltd. (Staryi Oskol), which manufactures a wide assortment of ceramic products for construction and sanitary-household applications, turned to Teplokhimmontazh Co. with a request to assist in replacing the linings of kiln cars in the ceramic brick shop, since the imported (Italian) lining was beginning to be unsuitable after seven years.

In order to maximally cover all of the requirements for the lining of kiln cars and ensure the optimum cost: quality parameter ratio, specialists at Teplokhimmontazh proceeded as follows. A new ceramoconcrete composite of aluminosilicate composition, ShML-40, in which the properties of mullite and chamotte materials are optimally combined, was developed. The high thermomechanical characteristics of the mullite phase, together with the specific features of the physicomechanical and structural parameters of the chamotte constituent allowed obtaining inexpensive unfired refractories of complex configuration maximally adapted to the conditions of service of tunnel kiln linings for firing ceramic brick.

In consideration of the available leading world and domestic experience, a car lining design was developed that makes it possible to rapidly perform complete major repairs of part of a car or partially replace its individual elements in taking them out of action during operation.

The basic properties of the materials used in the lining developed are reported in Table 1.

Side blocks made of ShKBI-5 ceramoconcrete composite with effective porosity to reduce heat losses are installed along the perimeter of the car. To protect from impact loads, linear slabs are placed on the blocks. They can quickly be replaced if they are damaged. The middle is filled with heat-insulating refractory material with a density of 400 kg/m^3. The floor slabs that protect the heat-insulating layer are then installed. The floor slabs and linear slabs are made of ShML-40 aluminosilicate ceramoconcrete. A grooved hearth made of channel stone 160 mm high is formed to eliminate underfiring of the lower rows of brick (see Fig. 1).

Based on the approved design, the lining was replaced in 50 cars by stages at OSMiBT Ltd. The first cares have already operated for more than 500 cycles (5 years) and are still operating. Work is now continuing to replace the linings of the entire kiln car fleet.

The reduction in the total weight and the good heat-insulating properties of the kiln car lining allowed conducting an industrial experiment on installing an additional row of brick together with specialists in the ceramic brick shop. Channel stones whose height was 120 mm less than those used were installed in five firing cars, and the height of the overall lining was reduced by 20 mm (from 330 to 310 mm) without perturbing the heat-shielding function. Based on the results of technical control, after passage through the kiln, the qualitative indexes of the finished product corresponded to the standards.

The calculations of ceramic brick shop specialists at OSMiBT Ltd. showed that when an additional (14th) row was installed in all cars, the productivity of the kiln increased by 18%.

A concrete lining was used in brick firing cars at Zheleznogorsk Brick Factory and ShA No. 5 chamotte brick was used as the support under the feedstock charge at Semiluki Refractory Factory. Rejects because of underfiring of the lower rows of brick were under 10%. The supports split after the first passages through the firing kiln. Running repairs were constantly being conducted on the existing Czech lining with refractory concrete based on alumina cement and chamotte filler. The concrete lining worked for no more than six months before repairs and restoration were required.

Teplokhimmontazh Co. specialists developed a plan for lining kiln cars in accordance with the technical assignment of the Zheleznogorsk Plant which would allow eliminating the indicated drawbacks and making it possible to install an additional row of brick. A design for channel stone of the arched type 80 mm high was also developed together with specialists from this factory. In all, the lining in 35 cars was replaced, and over three years with no repairs have elapsed since the first car was lined. Installation of hearth stones reduced rejects in the lower rows to 2%, and reducing the thickness of the lining as a result of improving its thermophysical indexes made it possible to install an additional row of sun-dried-brick batch.

After analyzing work of the lining installed at OSMiBT Ltd., representatives of the French company CERIC proposed replacing the face brick lining on 15 cars at the Saransk Plant where this company's kilns operate. A plan was developed for the kiln car lining in a short time and assemblies were manufactured and delivered. Contract supervision work on the first five cars with training of Saransk Plant personnel was executed under the direction of Teplokhimmontazh Co. specialists. The performance of the car lining is currently being monitored to make a final decision on replacing the linings in the entire fleet of cars.

In addition, in developing a partnership with CERIC and in accordance with the signed contract, improved ceramoconcrete linings were prepared for delivery in France for conducting capital repairs of the kiln cars at the ceramic brick factor in Marseille.

According to the calculations of Teplokhimmontazh Co. specialists, the guaranteed lifetime of the linings in firing cars made of composite aluminosilicate ceramoconcrete will be 5 years, or a minimum of 500 heating – cooling cycles.

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